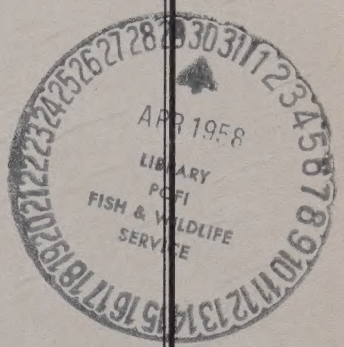
RIODICAL
1956
Internatl. Pacif. Salm. Fish. Comm.
Annual Report
1956

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

APPOINTED UNDER A CONVENTION
BETWEEN CANADA AND THE UNITED STATES FOR THE
PROTECTION, PRESERVATION AND EXTENSION OF
THE SOCKEYE SALMON FISHERIES IN
THE FRASER RIVER SYSTEM



ANNUAL REPORT
1956

COMMISSIONERS

ROBERT J. SCHOETTLER
A. J. WHITMORE
ELTON B. JONES
SENATOR THOMAS REID
ARNIE J. SUOMELA
H. R. MacMILLAN

NEW WESTMINSTER
CANADA
1957

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

MEMBERS
AND PERIOD OF SERVICE
SINCE THE INCEPTION OF THE COMMISSION
IN 1937

CANADA		UNITED STATES	
William A. Found	1937-1939	Edward W. Allen	1937-1951
A. L. Hager	1937-1948	B. M. Brennan	1937-1942
Senator Thomas Reid	1937-	Charles E. Jackson	1937-1946
A. J. Whitmore	1939-	Fred J. Foster	1943-1947
Olof Hanson	1948-1952	Milo Moore	1946-1949
H. R. MacMillan, C.B.E., D.Sc.	1952-1956	Albert M. Day	1947-1954
F. D. Mathers	1956-	Alvin Anderson	1949-1950
		Robert J. Schoettler	1951-
		Elton B. Jones	1951-
		Arnie J. Suomela	1954-

INTERNATIONAL PACIFIC SALMON
FISHERIES COMMISSION

APPOINTED UNDER A CONVENTION
BETWEEN CANADA AND THE UNITED STATES FOR THE
PROTECTION, PRESERVATION AND EXTENSION OF
THE SOCKEYE SALMON FISHERIES IN
THE FRASER RIVER SYSTEM

ANNUAL REPORT
1956

COMMISSIONERS

ROBERT J. SCHOETTLER
A. J. WHITMORE
ELTON B. JONES
SENATOR THOMAS REID
ARNIE J. SUOMELA
H. R. MacMILLAN

DIRECTOR OF INVESTIGATIONS
LOYD A. ROYAL

NEW WESTMINSTER
CANADA
1957

SETON CREEK DAM AND POWER DIVERSION

The diversion dam in the foreground, just below the outlet of Seton Lake, is 25 feet high and the diversion channel at the right will divert all but 400 cfs to a power house located on the Fraser River in the background. The project, owned by B.C. Electric Company, operates under 140 feet of head and produces 40,000 kw. The sockeye run using the fishway in 1956 totalled 9059 fish, all of which were destined for Gates Creek at the head of Anderson Lake.

REPORT OF THE INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION FOR THE YEAR 1956

The International Pacific Salmon Fisheries Commission has been conducting scientific research for nineteen years. Its investigations have been directed toward the many problems involved in the protection, preservation and extension of the sockeye salmon fishery of the Fraser River system under the terms of the Convention ratified in 1937. One of the most important factors arising from this scientific research has been the basic evidence that an intimate relationship exists between the sockeye salmon and its environment throughout its whole life history. That is, the sockeye are very sensitive animals who owe their existence today to the fact that over centuries of time they have become delicately adjusted to their environment—an environment which, with the exception of geological attributes, is controlled by the unvarying solar cycle. Similarly, the life cycles of the sockeye salmon are on strict hereditary time schedules. Throughout their lives their reproductive functions, growth and migrations coincide with their environmental conditions in such a way that this precise interrelation is absolutely essential to their survival.

The appreciation of this general fact of hereditary sensitivity is of practical importance in the programs for the rehabilitation and extension of the runs of sockeye salmon over the vast area of the Fraser River watershed. Furthermore, this fact is extremely pertinent to the question of industrial developments on the Fraser River for such developments could definitely create serious adverse factors affecting the reproduction of sockeye salmon. Before discussing the situation further, it is important to clarify the position of the Commission.

Since in a democracy it is the prerogative of the government, and not that of any single agency, to decide the course of resource development, the Commission does not have the right or the power to decide or control the use of the resources of the Fraser River. However, it is obligated under its terms of reference to state to the Government of Canada as well as to the Government of the United States the effects which the various proposed industrial developments will have on the sockeye salmon resource so that the government or governments concerned may arrive at intelligent decisions as to the actions to be taken to safeguard the continuing best interests of the people.

Whether the essential environment for sockeye salmon can be maintained in the Fraser River basin in the future will depend upon the character of the industrial developments. Through modern technological procedures it is possible to eliminate practically all types of deleterious water pollution and by the use of modern conservation practices timber can be harvested and land can be fully utilized without harm to the reproductive environment of the sockeye. It is the development of hydroelectric power, with its contingent dams, reservoirs and river diversions, that poses a serious threat to the restoration, maintenance and extension of the sockeye salmon fishery and even to its economic survival.

In considering the probable effects of changes in the environment on the sockeye salmon as a result of hydroelectric developments, it is necessary to review some of the details of the life history of the species.

The yearly runs of sockeye to the Fraser River are not homogeneous but are composed of a number of sub-populations, usually called races. Each race migrates through the commercial fishery waters at its own particular time and spawns consis-

tently in its home stream at a specific time. When the sockeye enter Juan de Fuca Strait they cease feeding and from that time on, involving in some cases a migration of 850 miles, they subsist on stored fat and body proteins. Spawning takes place under conditions of water temperature and flow which are remarkably consistent from year to year in each given reproductive area. The whole sequence of sockeye migration and spawning is adjusted to their store of energy materials and to the seasonal occurrence of water temperatures essential for successful migration and for the spawning activities, including nest building and effective spawning. The development of the egg, embryo and young fish is related to the seepage of water through the gravel and to the changes in water temperature from autumn to spring. The time of emergence of the fry from the gravel is related to temperature and light conditions and their entrance into the lake corresponds with the spring blooming of small food organisms. The young sockeye live for one (sometimes two years) in the lake, foraging on free-swimming animal plankton. In the spring of the second year of life undergoing certain physiological changes, they respond to a combination of biological and environmental factors and move *en masse* through the lakes, down the tributary streams into the main Fraser River and thence to the sea. Here they grow rapidly and in due course accumulate stores of energy according to their individual requirements for successful migration and reproduction. Early in their third year in the ocean, physiological changes occur and with these changes come specific responses to environmental conditions which eventually bring the fish back to the mouth of the river. A strong reaction induces them to swim upstream and possibly a conditioned response to the odors of their native waters leads them to their "home" lake and stream. Thus the life history of the sockeye salmon is completely adjusted to, or integrated with, the environmental cycle. As long as the delicate relationship between the fish and the environment remains stable, reproduction and survival is high, but changes in the environment can spell disaster because inherited responses are not readily adjustable to these changes. The set pattern of responses and the timetable of reproduction, growth and migration may be completely disrupted.

Evidence of the effects of "natural" changes in environmental conditions are many. In 1946, the Adams River run was delayed by low water conditions in the Fraser and Thompson Rivers and spawned much later than normal for this race. The effect of this delay was evident in the succeeding cycle year, 1950, the run being less than one-third the size of either of the runs of the two previous cycle years, namely, 1946 and 1942. On the other hand, because of emergency controls on the fishery the escapement in 1950 was reasonably good in numbers. The escapement was well timed in regard to temperature and produced in 1954 the largest run since 1913.

In 1955 unseasonably late high water in the Fraser Canyon near Yale delayed the Early Stuart run for six days. While the block lasted but a short time, only 2170 sockeye reached the spawning grounds out of an estimated 30,000 to 35,000 fish which arrived at the block area. This agrees with the findings at Hell's Gate where, from the results of tagging, it was found that any and all sockeye delayed for twelve days or more failed to reach the upper Fraser spawning grounds.

The construction of dams on the Fraser River will change conditions in many ways. A dam in itself forms an impassable barrier for the adult fish. Even if passage could be provided by the installation of the most modern fish passage facilities, delays in migration would be inevitable. The maximum extent and adverse effect of these

delays is somewhat difficult to assess because adverse factors are involved such as temperature and flow-pattern changes, particularly at powerhouse discharges. Furthermore, there is invariably some delay caused by the inability of the fish to find or accept the fishway and as fishways are of limited capacity, these at times become bottle-necks when very large numbers of fish are migrating. Even at the efficient Hell's Gate fishways a four-day delay occurred in 1954 during the Late Adams River escapement which was due in part to low water conditions and in part to the arrival of over a *million fish in a single day*. On the basis of extensive observations, a three day delay may be expected to occur at any dam which might be considered and as the number of dams is increased the total delay immediately becomes critical in relation to the energy reserves of the fish.

In 1956 the Commission, together with the Fisheries Research Board of Canada through its Technological Station in Vancouver, made a study of the expenditure of energy during the migration of the Early Stuart River sockeye where the fish made an uninterrupted journey of approximately 850 miles at the rate of about 30 miles per day. On the average, each fish started up the river with slightly over 12 ounces of oil, and after spawning, had one ounce remaining. Each fish also used up a considerable amount of its body protein reducing the body to one-third of its original dry weight. These reserve materials of oil and protein were utilized not only in supplying energy for swimming but in producing eggs and sperm and it is indicated from the study that a three or four day delay might be critical for this race. A lesser period of delay might lead to a deficiency of materials for egg production so that while the fish might still arrive on the spawning grounds they would be incapable of producing viable eggs. Extended delays, even without undue expenditure of energy, would result in arrival out of phase with the water temperature cycle thereby causing ineffective fertilization and out of phase development of the eggs.

A further factor to be considered in relation to the passage of sockeye at dams is that of fatigue and the rapid depletion of the body stores of energy materials during periods of delay and excessive activity. Recent researches indicate that strenuous activity resulting in muscular fatigue requires a minimum of two hours of rest for recovery and successive exposure to the maximum rate of energy expenditure has caused death. Furthermore it may be pointed out that the time and energy lost in finding upstream passage is not compensated for apparently by the absence of water current in the impoundment above because their migration distance has not been decreased and there is evidence that the fish do not increase their speed of migration in slack water.

Over and above the direct effect of dams on the fish there are indirect effects through changes in the environmental conditions. Impoundment of water above a spawning area usually changes the water temperature cycle affecting the spawning area. Reduction of water flow may decrease the amount of spawning area and change the physical character of the remaining portion while an increase of flow may render areas unsuitable by increasing the depth and velocity of the water. In either case the required spawning environment can be adversely affected and any of these effects could be sufficient to destroy the productive capacity of a spawning area as the whole behavior pattern in the spawning sequence of sockeye is most closely associated with the physical factors in the environment. Temperature of the water, velocity, depth and nature of the bottom materials are all related to the selection of spawning area, redd construction, pre-spawning "play" and "fighting", group association and the actual

spawning and covering of eggs. So it is that alterations in those conditions under which the salmon have become adjusted over long periods of time may have very adverse results. Undoubtedly the lack of knowledge of these inter-relations has been responsible for the failure of many attempts to successfully transplant sockeye from one area to another in the Fraser River watershed. Therefore, in attempting to restore runs to barren spawning areas, it is the Commission's present practice to select the donor stock from areas which have equivalent or similar ecological conditions and which are about the same distance from the sea.

In the spring the sockeye fry emerge from the gravel and move to the lake rearing area at a time when the spring plankton bloom provides them with an adequate food supply. Fry migrations are usually downstream but at two major spawning areas the migration is upstream. In the latter case, the fry follow the shore line closely where the velocities are low enough for them to swim upstream. It has been demonstrated that where this behavior pattern is followed, the creation of a slight obstacle to the upstream movement can exterminate the run and it is obvious that a significant increase in stream velocity would act as a barrier. The possible effect of changing water levels on the limnological conditions in the lake rearing areas occasioned by alternate storing and drawing down of water levels behind the dams is as yet not completely determined, but the production of food for young salmon could be reduced or changed in time of abundant occurrence and thereby could reduce the fish survival. At best it would be presumptuous to say that conditions would be improved.

After one year of lake residence, (occasionally two years), the young sockeye leave the lake on a seaward migration. They do so in relation to a combination of physiological and environmental changes. In the latter case, temperature, light and current appear to be important. In other words, there is a predictable pattern of timing which is related to the solar cycle modified only slightly by local weather conditions and therefore it is possible that a temperature barrier to migration might be produced readily in a dam impoundment under certain conditions. Unnatural impoundments in the migration path might also have an effect on the speed of seaward migration by reducing the current in which the young fish are normally carried downstream. A natural rate of migration is in all probability a necessity because of energy balance, physiological changes or the necessity for the sockeye to enter the sea when certain food organisms are abundant or when certain ocean currents are occurring which would take them to their ocean feeding grounds. Also, the known reticence of seaward migrants to enter by-passes would further delay their progress.

A further and extremely important effect of dams on downstream migrants is actual physical destruction. At a dam 100 feet high the mortality of young sockeye salmon passing over the spillway has been experimentally shown to be as high as 37%. At a dam 250 feet high the mortalities have been 64% over the spillway and 34% in the turbine. Even these figures may not tell the whole story because there may be insidious after effects such as delayed mortalities, increased predator loss and others. A great amount of money and effort has been expended in determining ways of safely by-passing young salmon over dams but despite this, no success has yet been experienced anywhere in full-scaled field tests.

Concerted action will be continued by the Commission, and by other fisheries agencies as well, in attempting to find means of reducing the many hazards of dam construction on salmon rivers. Whatever the outcome of these intensive studies may

be and whatever the decision may be as to the best use of the Fraser River resources, one thing must be kept constantly in mind—the sockeye salmon of the Fraser River are hereditarily unique and once lost they are lost for all time.

COMMISSION MEETINGS

The *first* meeting of the International Pacific Salmon Fisheries Commission during the year 1956 was held on January 21 in Seattle, Washington. Advisory Committee members present for Canada were: Mr. R. Nelson, salmon canners; Mr. H. A. Christenson, alternate member for the purse seine fishermen; Mr. P. Jenewein, gill net fishermen; Mr. H. North, troll fishermen; Mr. M. W. Black, sports fishermen. Representing the United States industry were the following Advisory Committee members: Mr. John Mitchell, alternate member for the salmon canners; Mr. N. Mladinich, purse seine fishermen; Mr. C. Karlson, gill net fishermen; Mr. John Brown, troll fishermen; Mr. H. Gray, sports fishermen. The proposed recommendations for regulation of the 1956 sockeye fishery, modified on the basis of previous representations by the Advisory Committee at an earlier meeting, were summarized and discussed. Representations from all Committee members were in concurrence that stringent regulations were necessary in 1956 in order to provide adequate escapements, and for this reason they were favorable to the recommended regulations as proposed. At a later session the Commission reviewed the regulatory requirements for the 1956 fishery in Convention waters and approved the final recommendations for submission to the respective governments. Consideration and approval was given both to a report on the downstream migrant guidance research which detailed the results achieved to date and to a proposed program for the conduct of additional investigation. The Engineering Consultant to the Commission reported on the past, present, and future power requirements of the Pacific Northwest.

The *second* Commission meeting of 1956, held on April 5 and 6 in Vancouver, B.C., was necessitated by the Canadian Government's rejection of the Commission's recommendations for control of the fishery in Canadian Convention waters for 1956 on the grounds that the recommendations constituted a radical departure from the limitations of Article IV of the Sockeye Salmon Fisheries Convention. To meet the objection to the suggested regulations, the Commission unanimously resolved to adopt the policy of issuing formal regulations covering all waters as set forth in Article I of the Convention and thereby strictly adhere to the provisions of Article IV of the Convention. Mr. George Brajcich was appointed Advisory Committee representative for the Canadian purse seine fishermen, replacing Mr. Wm. Pitre who had found it impossible to continue as a member because of personal business commitments. In a meeting with the Advisory Committee and members of the industry and press the following day, proposed regulations adhering to the strictest interpretation of the Convention were presented by the Commission with a discussion of the reasons for the various changes made from the recommendations adopted at the meeting on January 21. Objections were raised by the Advisory Committee to the newly proposed regulations and an additional meeting was scheduled to consider these objections. All members of the Advisory Committee were present except Mr. Black, representing the Canadian sports fishermen and Mr. Brown, representing the United States reef net fishermen.

A *third* meeting was held on April 13 in Bellingham, Washington with Mr. R. E. Walker acting as alternate representative for the Canadian salmon canners, Mr. G.

T. Brajcich being present in his newly appointed capacity as representative of the Canadian purse seine fishermen and Mr. H. North, the Canadian representative for the troll fishermen being absent. Revised regulations were presented to the Advisory Committee who agreed that these were acceptable insofar as regulations adhering strictly to the Convention could be made acceptable. The Commission adopted the regulations for 1956 as accepted by the Advisory Committee and authorized its Secretary to legally publish a true copy of the adopted regulations in a daily newspaper in New Westminster, B.C. and a daily newspaper in Bellingham, Washington.

The *fourth* Commission meeting of the year was held on July 27 in New Westminster, B.C. The Director presented the detailed budget estimates for the 1957-58 fiscal year which allowed for increased activity on engineering and biological research relating to dams and artificial spawning grounds. The budget estimates were approved together with an action calling for the construction of the necessary fishways to overcome any future delays to sockeye migration in the Fraser River near Yale, British Columbia. A review was made of catch-escapement ratios and of the problems relevant to division of the catch as of that date.

The *fifth* meeting of the year was held September 27 and 28 in Vancouver, B.C. Mr. Fred D. Mathers was welcomed to his first meeting following his appointment as the Canadian Commissioner to replace Mr. H. R. MacMillan, who had resigned after serving on the Commission since 1952. All members of the Advisory Committee with the exception of Mr. H. Gray were present, as well as interested persons from the industry, fisheries agencies and the press. The main purpose of the meeting was to acquaint the Advisory Committee and the industry generally with the problems of maintaining a sensible and practical management program for the Fraser River sockeye fishery. Reports were given on the 1956 sockeye catch and escapement and on the problems resulting from changes in gear, fishing intensity and increased fishing area. The Director reviewed the complications of increased gear intensity, as well as increased gear efficiency, and an expanding high seas fishery with respect to the 1957 regulations. The Chairman advised the meeting that the Commission had two recommendations to make to the two governments, subject to the advice and comment of the Advisory Committee. These were:

(a) That all high seas areas and the adjacent territorial waters excepting rivers, bays and estuaries off the Coasts of the United States and Canada be closed to all salmon net fishing.

(b) That it was necessary for the Commission to have the right to control fishing in any or all parts of Convention waters, except waters set aside as national salmon preserves where no commercial salmon fishery is permitted.

The Advisory Committee approved the recommendations, and it was agreed that they be submitted to the respective governments as suggested. A complete resume of proposed hydroelectric power development in the Fraser River watershed was presented to the Committee.

The *sixth* and final meeting of 1956 was held December 12 and 13 in Bellingham, Washington. Staff members presented field reports covering the most important problems of research and management involved in the Commission's fulfillment of its duties under the Convention. Subjects surveyed included the following:

1. A critical examination of ten years of salt water tagging at Sooke and its limitations for use in management of the fishery.

2. Racial fishing mortalities during the 1955 and 1956 sockeye fishing season.

3. A study of the possible relationship between the phase of the moon and the timing of certain sockeye runs approaching the mouth of the Fraser River.

4. The use of test fishing in the Fraser River near Albion and daily catch statistics as a measure of the size of escapement during fishing closures.

5. An analysis of the size trends of sockeye salmon from 1915 to 1955.

6. A study of stored energy consumption by sockeye during their upstream migration and its relation to the problems created by dams.

7. The physical characteristics of the principal sockeye spawning grounds and rearing areas and optimum spawning escapements indicated by these characteristics.

8. A study of the hydraulics of flow through gravel beds and the effect of flow distribution on survival of sockeye eggs.

9. A report on an investigation to determine the effect of turbid water on conditions within gravel beds as related to the survival of sockeye eggs.

10. Methods of ascertaining the survival rate of sockeye at three stages in their life cycle at Chilko Lake with results obtained over an eight year period.

11. A study of the distribution of sockeye underyearlings in Shuswap Lake.

12. A study of the distribution of sockeye underyearlings in Chilko Lake.

13. A study of the characteristic scale differences in sockeye reared in Lillooet and Harrison Lakes and an estimate of the distribution of fry, underyearlings and yearlings in the two lakes.

14. A measure of the relative abundance of food of sockeye underyearlings in the various lakes of the Fraser River watershed.

15. Results of a study on the possible relationship between sockeye and kokanee populations.

16. A study of the relationship between Kamloops trout and juvenile sockeye populations in Shuswap Lake.

17. Methods of rehabilitating barren or depleted streams by transplantations of fingerlings and "eyed" eggs.

18. The physical design of artificial spawning grounds at the Quesnel Field Station in 1953, 1955 and 1956.

19. Artificial spawning ground experiments and the results obtained from two separate experiments.

20. A study of theoretical river water temperatures prior to the period covered by available records to determine whether there are any long term trends in the water temperature in major spawning areas.

21. A study of the temperature limitations of various races of sockeye and the relationship of gravel and surface water temperatures.

22. A study of population dynamics in relation to maximum productivity.

23. A report on the purpose, design and progress in construction of the Yale fishways.

24. A report on experiments in guiding of sockeye migrants and adults by electric screens.

25. A report on the proposal of the B.C. Power Commission to divert water from Chilko and Taseko Lakes for hydroelectric power development.

26. A report on the inaugural investigations being conducted to determine the effect of a high dam on the Fraser River.

TABLE I

SOCKEYE CATCH BY GEAR

UNITED STATES TREATY WATERS

	Purse Seines			*Gill Nets*			*Reef Nets*			*Total*
Year	*Units*	*Catch*	*Percentage*	*Units*	*Catch*	*Percentage*	*Units*	*Catch*	*Percentage*	*Catch*
1944	57	335,172	76.97	45	40,620	9.33	31	59,651	13.70	435,443
1948	185	940,415	86.35	130	70,991	6.52	71	77,685	7.13	1,089,091
1952	207	826,304	74.21	195	175,064	15.72	66	112,107	10.07	1,113,475
1956	164	428,562	47.26	491	371,729	40.99	85	106,581	11.75	906,872

CANADIAN TREATY WATERS

	Purse Seines			*Gill Nets*			*Traps*			*Total*
Year	*Units*	*Catch*	*Percentage*	*Units*	*Catch*	*Percentage*	*Units*	*Catch*	*Percentage*	*Catch*
1944	0	0	0	1,580	974,529	97.08	4	29,297	2.92	1,003,826
1948	14	14,511	1.93	1,067	663,635	88.17	5	74,545	9.90	752,691
1952	41	122,114	10.58	1,470	966,852	83.75	5	65,417	5.67	1,154,383
1956	50	216,388	24.18	1,151	678,074	75.78	0	0	0	894,836

Note: Gear counts represent the maximum number of units delivering on any single day.

Table II

CYCLIC LANDINGS AND PACKS OF SOCKEYE

	United States	*Canada*	*Total*
*1956			
Total landings (No. Sockeye)	906,872	894,836	1,801,708
Share in Fish	50.33%	49.67%	
Total Pack (48 Lb. Cases)	84,052	84,296	168,348
Share in Pack	49.93%	50.07%	
1953-1956			
Total Landings (No. Sockeye)	8,752,177	8,717,722	17,469,899
Share in Fish	50.10%	49.90%	
Total Pack (48 Lb. Cases)	849,007	842,575	1,691,582
Share in Pack	50.19%	49.81%	
1949-1952			
Total Landings (No. Sockeye)	4,527,955	4,357,813	8,885,768
Share in Fish	50.96%	49.04%	
Total Pack (48 Lb. Cases)	429,794	412,353	842,147
Share in Pack	51.04%	48.96%	
1956 CYCLE PACK			
1956	84,052	84,296	168,348
1952	114,638	115,814	230,452
1948	90,441	61,650	152,091
1944	37,379	88,150	125,529
1940	59,354	93,361	152,715
**1936	59,505	184,854	244,359
1932	81,188	65,769	146,957
1928	61,044	29,299	90,343
1924	69,369	39,743	109,112
1920	62,654	48,399	111,053
1916	84,637	32,146	116,783
1912	184,680	123,879	308,559
1908	170,951	74,574	245,525
1904	123,419	72,688	196,107

* 14 Canneries in the United States and 10 canneries in Canada received the sockeye caught in Convention waters.

** 1904 to 1936 from Pacific Fisherman, 1948 Yearbook Number, p. 139.

1956 REGULATIONS

Recommendations for regulations governing the 1956 sockeye fishery in Convention waters were adopted at a meeting of the Commission held with its Advisory Committee in Seattle, Washington, on January 21, 1956. The regulatory recommendations were submitted to the Governments of the United States and Canada on January 26, 1956 but the recommendations for regulatory control of Canadian Convention waters were rejected by the Canadian Government on the grounds that they constituted a radical departure from the limitations of Article IV of the Sockeye Salmon Fisheries Convention.

New regulations were drafted by the Commission within the legal terms of reference of the Sockeye Salmon Fisheries Convention. The new regulations were presented to the Advisory Committee at two separate meetings and were adopted by the Commission on April 13, 1956 as the Regulations controlling the taking of sockeye in Convention waters during 1956. The adopted Regulations were published on May 11, 1956 in the British Columbian, New Westminster, B.C. and in the Bellingham Herald, Bellingham, Washington.

The published regulations for sockeye fishing in Convention waters for 1956 were as follows:

"Under the authority of the Convention between the United States of America and His late Majesty the King in respect of Canada, for the protection, preservation and extension of the Sockeye Salmon Fisheries in the Fraser River System, signed at Washington on the 26th day of May, 1930, the International Pacific Salmon Fisheries Commission at its meeting at Bellingham in the State of Washington, United States of America, on the 13th day of April, 1956, hereby makes and adopts the following Orders and Regulations by the affirmative votes of two of the Commissioners on the part of the United States of America and three of the Commissioners on the part of the Dominion of Canada, to wit:

1. The taking of sockeye salmon in the Territorial Waters and on the High Seas embraced in paragraph numbered 1 of ARTICLE I of the said Convention is not and shall not be prohibited to the nationals or inhabitants or vessels or boats of the Dominion of Canada or the United States of America at any time during the period commencing on the 28th day of June, 1956 and extending until and including the 5th day of August, 1956; and the said Commission hereby approves of salmon fishing gear and appliances consisting of a lure, drawn behind a boat or other floating equipment of any kind, commonly known as trolling fishing gear and appliances, being used on such Territorial Waters and High Seas by said nationals, inhabitants, vessels or boats at any time or times during said period; and the said Commission hereby orders that no salmon fishing gear or appliances other than that approved above shall be used on such Territorial Waters and High Seas by said nationals, inhabitants, vessels or boats at any time or times during said period.
2. The taking of sockeye salmon in the Canadian waters embraced in paragraphs numbered 2 and 3 of ARTICLE I of the said Convention is and shall be prohibited from five o'clock in the forenoon of Friday of each week to five o'clock in the forenoon of Tuesday following in the period commencing on the 28th day of June, 1956 and extending until the 14th day of August, 1956, both dates inclusive.
3. The taking of sockeye salmon in the Canadian waters embraced in paragraphs numbered 2 and 3 of ARTICLE I of the said Convention is and shall be prohibited from seven o'clock in the forenoon of Thursday of each week to

seven o'clock in the forenoon of Tuesday following in the period commencing on the 15th day of August, 1956 and extending until the 13th day of September, 1956, both dates inclusive.

4. The taking of sockeye salmon in the Canadian waters embraced in paragraphs numbered 2 and 3 of ARTICLE I of the said Convention is and shall be prohibited during the period commencing at seven o'clock in the forenoon of the 13th day of September, 1956 and extending until seven o'clock in the forenoon of the 19th day of September, 1956.
5. The taking of sockeye salmon in the waters of the United States of America embraced in paragraph numbered 2 of ARTICLE I of the said Convention is and shall be prohibited from five o'clock in the forenoon of Friday of each week to five o'clock in the forenoon of Monday following in the period commencing on the 28th day of June, 1956 and extending until the 9th day of August, 1956, both dates inclusive.
6. The taking of sockeye salmon in the waters of the United States of America embraced in paragraph numbered 2 of ARTICLE I of the said Convention is and shall be prohibited from eight o'clock in the afternoon of Friday of each week to eight o'clock in the afternoon of Sunday following in the period commencing on the 10th day of August, 1956 and extending until the 2nd day of September, 1956, both dates inclusive.
7. Where any hour of time is mentioned in any of the foregoing Orders and Regulations the time so mentioned shall be held to be what is commonly known as Pacific Standard time, which shall be reckoned as 8 hours behind Greenwich time."

Three modifications were made in the 1956 regulations, two of these governing sockeye fishing in Canadian Convention waters and one governing sockeye fishing in United States Convention waters.

The first modification in the regulations was a twenty-four hour extension of the weekly close time in Canadian Convention waters commencing Friday, August 3, and extending to Wednesday, August 8. This action was deemed necessary to provide escapement and to obtain division of the catch between the two countries.

The second amendment to the Regulations affecting Canadian Convention waters was issued on September 7. This amendment closed Canadian Convention waters to the use of linen gill nets of less than 8 inches extension measure and nylon gill nets of less than 8¾ inches extension measure during the period commencing at 7:00 a.m. September 10 and extending to 7:00 a.m. September 14 in order that the run of white spring salmon might be reasonably exploited.

Upon termination of the closure of Canadian Convention waters from September 14 to September 19 for the protection of sockeye, the statutory weekly close times of the Department of Fisheries were in effect until October 12 when an additional twenty-four hours per week was imposed for the protection of chum salmon stocks.

A special closure to allow for spawning escapement of species other than sockeye was promulgated by the Department of Fisheries from 8:00 a.m. October 29 to 8:00 a.m. November 12. All salmon net fishing was similarly closed for the balance of the season at 8:00 a.m. November 15.

By August 6 the extremely heavy concentration of fishing gear in United States Convention waters made it evident that a stringent curtailment of fishing time was necessary if the Commission was to fulfill its terms of reference under the Convention. Consequently the Orders and Regulations of April 13 were amended to add thirty-

Table III

DAILY CATCH OF SOCKEYE, 1944 - 1948 - 1952 - 1956 FROM UNITED STATES TREATY WATERS

Date	JULY				AUGUST				SEPTEMBER			
	1944	1948	1952	1956	1944	1948	1952	1956	1944	1948	1952	1956
1			5,011		58,863	118,062	40,805	59,168	26	2,707	714	2
2			8,640	4,286	46,797	100,423		41,245		391	598	0
3	4		7,943	3,885	28,550	97,469			49	1,150	433	1,423
4			4,857	2,365	20,117	67,360	32,815		44		435	609
5				1,038		60,695	25,891		65	1,297	140	506
6	18				9,370	68,962	16,978	141,985	55	3,799		457
7	99		14,008		6,912		18,488	99,049	19	1,692	723	146
8		CLOSED	9,369		9,221	115,925	13,920	331	6	404	203	1
9	133		8,090	2,429	3,859	101,997		1,405		333	578	2
10	163		6,796	1,803	3,139	38,878		333	21	134	636	78
11	93		4,187	2,189	5,788	17,288	6,865	282	39		557	59
12	127			1,423			7,055	206	6	212	410	34
13	150				1,855		2,697	24,464		205		120
14	241		9,159		2,272		2,712	21,534	20	65	434	109
15			10,812		383		2,831	12,571	2	15	299	0
16	1,490		13,794	4,677	1,242			9,174		42	272	0
17	1,292		16,876	8,146	935			24	28	140	193	43
18	2,669	1,900	11,786	12,101	423		4,096	61	28		202	146
19	3,836	2,469		15,053		2	3,143	42	3	233	151	49
20	9,351	6,348			1,395		2,730	13,231	5	88		23
21	9,313	8,622	90,696		1,612	0	967	8,940	17	20	117	37
22		5,671	32,619		222	7	612	4,965	4	24	135	0
23	11,272	5,142	34,320	78,518	59		0	2,296		11	86	0
24	14,840		110,491	59,695	18			8	6	16	49	3
25	11,952	17,524	134,294	39,052	76		220	80	1		48	3
26	17,100	22,251		31,635			720	46	1	16	34	4
27	25,144	23,441			51		1,168	702	1	22		5
28	19,183	42,887	128,339		150		1,310	747	1	429	20	5
29		69,529	100,767		243		931	407		811	20	0
30	46,334	78,843	96,565	113,200	192			529		319	31	
31	56,431		56,664	70,572	17		655	12				
Totals	231,235	284,627	916,083	452,067	203,761	787,068	187,609	443,837	447	14,575	7,518	3,864
June Total			2,134	7,066								
Oct. Total										2,821	131	38
Season Total									435,443	1,089,091	1,113,475	906,872

Table IV

DAILY CATCH OF SOCKEYE, 1944 - 1948 - 1952 - 1956 FROM CANADIAN TREATY WATERS

Date	JULY				AUGUST				SEPTEMBER			
	1944	1948	1952	1956	1944	1948	1952	1956	1944	1948	1952	1956
1			10,225		98,603		11,392	82,824		2,149	13,562	
2			8,532		91,273	62,634		59,665		2,757	5,599	
3	218		12,241	8,563	89,969	54,876				15	3,343	37
4	228		1,184	4,738	69,713	58,060	811		1,813		6,475	4,404
5	328			6,508		74,788	108,955		1,834		10	1,449
6	396					18,427	36,472	20,813	2,689	2,830		5
7	711		13,476		85,516		23,048	13,758	1,714	1,028		4
8		CLOSED	10,009		31,746		911	154,079		388	8	
9			8,732		34,491	101,965		78,204		385	7	
10	1,852		9,000	4,778	24,922	62,668		6,142		11	7	180
11	1,360		1,317	2,786	22,513	39,454	38,878		458		11	585
12	1,572			2,479		35,812	12,321		413		12	260
13	2,286					1,645	11,433	2,348	284	1,927		42
14	2,868		13,063		12,203		9,381	53,092	576	1,437		1
15			8,249		5,933		110	15,776		1,663	28	
16			13,221		8,641	30,941		2,590		1,789	28	
17	5,119		22,896	7,581	8,117	24,102		563		3	27	0
18	5,722		11,729	7,076	9,424	13,438	17,786		3,018		17	3
19	5,486	1,281		9,465		11,031	9,714		3,175		17	6,917
20	5,058	1,281				97	6,218	776	1,567	3,117		2,753
21	13,961	1,283	5,299		16,981		5,443	17,452	1,226	931		1
22		637	5,299		4,696		67	5,806		703		
23			5,299		3,290	15,618		665		859		
24	45,821		39,207	57,040	2,535	8,322		559		0		1,383
25	22,035		48,841	22,615	80	8,302	21,489		5,574		1	193
26	18,488	2,912		29,244		7,525	9,583		1,232		1	94
27	15,723	2,967				84	6,535	281	488	5,523		29
28	12,229	16,769	211,103		9,138		5,162	6,903	704	3,130		0
29		11,248	109,483		1,632		13	2,869		2,216	2	
30		23,567	79,096		1,275	2,241		69		1,650	2	
31	170,205		120,159	181,983	936	1,623		23				
Totals	331,666	61,945	767,660	344,856	633,627	633,653	335,722	525,257	26,765	34,511	29,157	18,340
May and June Totals	529	879	15,386	5,351								
Oct. and Nov. Totals									11,239	21,703	6,458	1,032
Season Total									1,003,826	752,691	1,154,383	894,836

TABLE V

THE INDIAN CATCHES OF SOCKEYE SALMON BY DISTRICTS AND THE VARIOUS AREAS WITHIN THESE DISTRICTS, 1952, 1956

District and Area	1952 *Catch*	1952 *No. of Fishermen*	1956 *Catch*	1956 *No. of Fishermen*
HARRISON-BIRKENHEAD				
Skookumchuck and Douglas	1,686	10	1,685	11+
Birkenhead River	9,679	29	6,953	22
Totals	11,365	39	8,638	33+
LOWER FRASER				
Laidlaw to Vedder River	2,545		3,045	
Seabird Island and Adjacent Area			1,855	
Katz and Ruby Creek	6,310		710	
Totals	8,855		5,610	
CANYON				
Union and American Bars	806		510	
Yale	4,979		1,950	
Spuzzum	961		360	
Boston Bar	1,331		480	
Boothroyd	1,441		1,150	
Cisco	3,522		1,800	
Totals	13,040		6,250	
LYTTON-LILLOOET	6,674	49*	4,585	47*
Gates Creek	2,000		——	
Totals	8,674	49*	4,585	47*
BRIDGE RIVER RAPIDS				
Lillooet	4,314	37	2,958	35
Rapids	10,337	51	7,103	49
Pavillion	4,154	19	2,854	18
Totals	18,805	107*	12,915	102*
CHILCOTIN				
Farwell Canyon	2,056		1,833	
Hance's Canyon	3,391		1,293	
Alexis Creek	2,372		3,423	
Siwash Bridge	4,330		5,161	
Keighley Holes	——		——	
Totals	12,149	72*	11,710	64*
UPPER FRASER				
Shelley	232		85	
Alkali and Canoe Creek	550		250	
Chimney Creek	1,808		743	
Soda Creek	365		110	
Alexandria	145		45	
Quesnel	385		72	
Totals	3,485	89*	1,305	79*
NECHAKO				
Nautley Reserve	942	10	2,353	10
Stella Reserve	1,242	16	2,154	11
Totals	2,184	26	4,507	21
STUART				
Fort St. James	1,946	35	1,916	32
Tachie Reserve and Pinchi	1,162	21	648	23
Trembleur Lake and Takla Lake	113	2	——	
Totals	3,221	58	2,564	55
THOMPSON				
Nicomen Creek	1,157			
Ashcroft	——		619	
Deadman's Creek	——			
North Thompson River	——		310	
South Thompson River	1,568		375	
Main Thompson River			2,800	
Totals	2,725		4,104	
GRAND TOTALS	84,503		62,188	

* Number of Permits issued to Indians in District.

The Indian catch statistics detailed above are obtained principally from the Fisheries Inspectors of the Canadian Department of Fisheries. These inspectors control the taking of sockeye for food by the various Indian populations residing throughout the Fraser River Watershed.

nine hours to the weekly close time for the second week in August making it extend from 5:00 a.m. August 8 to 8:00 p.m. August 12. Also at this time the weekly close time for the period August 12 to September 2 was increased from forty-eight hours to seventy-two hours. After September 2 the United States fishery reverted to a forty-eight hour weekly close time under regulations issued by the Director of the Washington State Department of Fisheries.

THE UNITED STATES FISHERY

In recent years each annual report of the Commission has emphasized the serious effect of increasing gear efficiency and the increasing numbers of fishing units on the regulations affecting the United States fishery. It has become obvious that the change over from linen to nylon gill nets in 1951, the addition of the power block to the purse seine in 1955, and the increasing numbers of gill nets can only result in less fishing time. Fishing efficiency in United States waters is becoming so high that the fishing period is too short for sound economic operation and stable administration. The following table effectively demonstrates the necessity of the short fishing periods and the rapid rise in the ability of the United States fishing fleet to take its share of the cyclical run.

Year	United States Catch	United States Gear			Fishing Days Per Week	Percentage Escapement
		R.N.	P.S.	G.N.		
1956	906,872	85	164	491	3*	32.05%
1952	1,113,475	66	207	195	5	26.59
1948	1,089,091	71	185	130	6	34.09

* Although fishing in 1956 was permitted for four days a week for most of the season, fishing in one week was reduced to two days during the peak of the run. It is calculated that a **three day week in 1956** without adjustment would have provided a better balanced escapement to all areas and the same total season catch.

A detailed record of the cycle year catches of sockeye in United States Convention waters is presented in Tables I, II and III.

In respect to the excessive gear efficiency in United States waters, it should be emphasized that the Commission is specifically restricted from controlling gear in any manner except in regard to fishing time. Partial-day fishing would be advantageous to the proper management of the fishery since it would reduce the daily catch, balance the catch more evenly throughout the fishing area and increase the number of days during which fishing would be conducted. Partial-day fishing, however, involves serious patrol problems since gill net fishing would of necessity have to start or stop during the hours of darkness. Such a measure also would not be the answer to the complex problem created by increased efficiency of gear. For these reasons the Commission has been reticent to recommend partial-day fishing.

THE CANADIAN FISHERY

The basic problem in gear regulation in Canadian Convention waters has been created by the addition of Juan de Fuca Strait as an effective gill net and purse seine fishing area. The historic Fraser River gill net fishery for many years has been capable, when operating, of taking an estimated 98 per cent of the fish available. In addition to this high efficiency there has been a supersaturation of gear which allows a substantial reduction in the number of units of gear normally operating without any measurable reduction in fishing efficiency.

A large fleet of gill net boats can leave the Fraser River area for Juan de Fuca Strait without reducing the 98 per cent fishing efficiency of the residual Fraser River fishing fleet. The catch of the gill net fleet in Juan de Fuca Strait is now reaching substantial proportions, and when combined with the increasing catch of purse seines in the same area, it is obvious that a substantial reduction must be made in the fishing time of both areas if adequate escapement is to be secured.

The changing distribution of the catch by fishing area in Canadian Convention waters is best illustrated by the following table. It should be noted that, lacking a major fishery by other gear a substantial percentage of the catch in Juan de Fuca Strait was taken by traps in 1944, 1948, and 1952. The traps did not operate in 1956, hence the entire catch for that year in the latter area was taken by the rapidly expanding gill net and purse seine fisheries.

Cycle Year	Per cent of Catch taken in Fraser River Area	Per cent of Catch taken in Juan de Fuca Strait
1956	65.30	34.70
1952	83.95	16.05
1948	88.17	11.83
1944	97.08	2.92

In 1956, when quality of the catch in the Fraser River area was not a factor and the expected size of the total season's run was relatively small, the Commission approved recommendations for closing the San Juan fishery as being in the best interests of proper management of the entire fishery. Although generally supported by the fishing industry these recommendations were not carried out since they were beyond the regulatory powers as specified by the Sockeye Fisheries Convention.

Under the provisions of the present Convention which requires uniform regulations for both Juan de Fuca Strait and the Fraser River, the increasing fishing fleet in Juan de Fuca Strait can only result eventually in a two day fishing week throughout the Canadian fishery during the early runs of sockeye. Such a fishing week is entirely impractical according to the industry and it certainly is impractical to the management agency.

A detailed record of the cycle year catches of sockeye in the Convention waters of Canada is presented in Tables I, II and IV.

ESCAPEMENT

The total 1956 run of sockeye to the Fraser River system including the commercial catch, Indian catch and the escapement was 2,743,000 fish, representing a decline of 14.4 per cent over the run of the previous cycle in 1952. In spite of substantial increases in fishing efficiency the fishing regulations were so designed that the total escapement of 879,000 to all spawning areas actually increased by 3.2 per cent over the escapement in 1952.

The 1956 escapement is considered to be satisfactory even though the numbers of spawners were below those recorded in most areas in the previous cycle year. The Chilko run is now the principal supporter of the cycle run and the escapement to this area was estimated to be substantially greater than is believed necessary to produce a maximum returning run. Substantial numbers of fish were found spawning in non-productive areas which is a positive indication over and above spawning density studies that surplus escapement occurred.

Table VI

SUMMARY OF THE SOCKEYE ESCAPEMENT TO THE FRASER RIVER SPAWNING AREAS, 1944, 1948, 1952, 1956

District and Streams	*Period of Peak Spawning*	*Estimated Number of Sockeye*				*Jacks*	*Sex Ratio* *Males* 4-5 yr.	*Females* 4-5 yr.
		1944	1948	1952	1956			
LOWER FRASER								
Cultus Lake	Nov. 18-25	14,200	13,086	18,910	14,133	415	4,630	9,088
Upper Pitt River	Sep. 14-18	Present	53,000	48,887	32,258	0	15,047	17,211
Widgeon Slough	Oct. 28-Nov. 5	1,050	——	1,648	1,000	81	459	460
HARRISON								
Big Silver Creek	Sep. 12-16	5,192	12,000	6,031	6,187	0	3,093	3,094
Harrison River	Nov. 10-14	——	26,000	25,794	3,184	0	1,623	1,561
Weaver Creek	Oct. 20-24	16,441	20,000	33,983	8,472	200	2,912	5,360
LILLOOET								
Birkenhead River	Sep. 18-21, Oct. 2-5	57,707	120,000	79,082	57,899	8,145	18,828	30,926
SETON-ANDERSON								
Gates Creek	Aug. 26-31	——	——	6,883	9,059	47	3,965	5,047
SOUTH THOMPSON								
Seymour River	Aug. 25-27	200	4,000	6,785	2,684	78	1,361	1,245
Lower Adams River	Oct. 28-30	1,367	12,600	8,692	7,512	691	2,314	4,507
Little River	Oct. 25-26	200	2,400	1,964	661	465	67	129
Scotch Creek	Sep. 7-10	0	50	357	163	155	0	8
South Thompson R.		0	100	200	0	0	0	0
NORTH THOMPSON								
Raft River	Aug. 28-Sep. 1	1,082	10,500	15,819	9,582	0	3,727	5,855
CHILCOTIN								
Chilko River	Sep. 22-25	328,655	670,000	489,473	647,479	837	260,303	386,339
Taseko Lake	Aug. 26-29	——	Present	3,647	1,995	1	647	1,347
QUESNEL								
Horsefly River	Aug. 31	3	50	7,013	2,944	2,860	42	42
Mitchell River					14	14	0	0
NECHAKO								
Endako River	Sep. 5-7	1	0	146	18	2	8	8
Nadina River	Aug. 26-28, Sep. 21-23	——	30	1,677	1,311	112	458	741
Nithi River	Aug. 25-27	——	1	45	36	0	18	18
Ormonde Creek	Aug. 25-26	15	150	996	331	0	109	222
Stellako River	Sep. 24-27	3,294	16,000	40,462	38,459	21	15,754	22,684
STUART								
Early Runs								
Driftwood River	Aug. 15-18	——	——	38	50	14	18	18
Forfar Creek	Aug. 1-4	46	1,500	6,975	5,497	24	1,928	3,545
Gluske Creek	Aug. 1-4	——	1,500	5,911	4,619	10	1,320	3,289
Kynoch Creek	Aug. 1-4	350	7,500	13,439	9,535	51	3,245	6,239
Narrows Creek	Aug. 6-10	0	0	1,453	697	11	193	493
Rossette Creek	Jul. 31-Aug. 3	2	1,500	3,575	3,863	12	991	2,860
Shale Creek	Aug. 6-10	——	0	414	185	2	90	93
Misc. Streams	Aug. 8-12	——	——	1,775	711	13	347	351
Late Runs								
Kazchek Creek	Sep. 11-15	3	80	295	223	128	47	48
Middle River	Sep. 12-15	22	200	476	500	166	136	198
Tachie River	Sep. 15-18	——	20	364	600	200	176	224
Sakeniche River	Sep. 15-18				131	47	42	42
NORTHEAST								
Upper Bowron R.		1,700	25,218	18,672	6,996	2	2,872	4,122
TOTALS		431,530+	997,485	851,881	878,988	14,804	346,770	517,414

The excess escapement to Chilko which resulted from emergency closures in the fishery is direct evidence of the serious management problem involved in an increasing fishery having an increasing efficiency. Fishing time is so restricted and the open period of fishing in the several major fishing areas so effective that a minor change in fishing time for the purpose of either providing the desired escapement or equal division of the allowable share of the catch has a major effect on the catch, escapement and division of the catch.

Increased fishing time through the reduction of the fishing fleet, fishing efficiency or fishing area depending upon which method or methods are most practical is essential to eliminating the danger of underfishing, overfishing or unbalanced catch between the fishermen of Canada and the United States.

The decline in the 1956 run as well as the decline in the 1955 run is believed to be caused by poor ocean survival. Indication that ocean survival has been below that of the previous two years may be found in the following data obtained during certain stages in the life history of the Chilko run.

Spawning Year	Egg to Fry Survival	Fry to Migrant Survival	Adult Survival
1949	6.71%	—	18.54%*
1950	10.27%	—	11.50%*
1951	13.12%	56.65%	5.49%
1952	6.04%	52.02%	7.08%

* Estimated.

REHABILITATION OF BARREN AREAS

The terms of reference of the Commission require that the sockeye runs of the Fraser River system be restored and where possible extended by establishing new spawning and rearing areas through the use of artificial aids. With the advent of new power requirements to meet the needs of the growing industrial community in British Columbia, power proponents are now suggesting that existing runs of sockeye which might be affected by power development be transplanted to other areas or supported by artificial propagation. It seems pertinent therefore to summarize the studies of the Commission which are as yet mostly unpublished.

The sensitive and intimate relationship of Fraser River sockeye to their fresh water environment is well established and is referred to previously in this report. The adverse effects of delay in migration at Hell's Gate between 1913 and 1945 and the increased productivity of sockeye passing Hell's Gate beginning in 1945 when the first fishways became operative is outstanding evidence of the sensitivity of this relationship. Seventy-nine sockeye transplantations undertaken between 1902 and 1936, before the practice of artificial propagation was abandoned by the Canadian Government in the Fraser River watershed, failed in each instance to provide beneficial results. It was the failure of these many experiments conducted at great expense together with the vast amount of data collected by the Commission relating the sockeye to their environment that forced the Commission at the outset of its work in rehabilitating barren spawning ground to improve on the trial and error method of transplantation. New information on the relationships of sockeye to their environment was applied in the hope of increasing the effectiveness of transplants.

Donor stocks were sought which spawned in areas located about the same distance from the sea as the areas contemplated for restocking. It was required that the water

temperature cycle during the period of spawning and incubation in both the donor and recipient areas be approximately the same. In spite of these rigid requirements, the twelve transplants of healthy fingerling stock carried out between 1949 and 1956 failed in their purpose of returning a transplanted stock of spawners to a barren spawning area located in another watershed.

Even though the artificial propagation of salmon and trout has been carried out extensively for over eighty years, little is known about the physiological effect of changing the natural environment during spawning and incubation through the use of artificial propagation methods. The survival of artificially propagated salmonoids seldom, if ever, equals that of naturally propagated fry or fingerlings. Pending the findings from their studies of the physiological effects of artificial propagation, the Commission inaugurated two eyed-egg transplantation experiments in 1950 using the same criteria described above for the donor and receiving streams. Both of these experiments were a success in returning a run of adult spawners to the planted streams. In 1950, 667,000 eggs taken and eyed in the Seymour River were planted in the gravel beds of the Upper Adams River and returned 205 spawners to the latter area in 1954. The returning adults spawned successfully at a favorable water temperature and in the area where the eggs were planted although many miles of potential spawning grounds were available to them. A similarly successful eyed-egg transplant in 1950 from Lower Adams River to Portage Creek returned 3505 adult spawners to the recipient stream in 1954. Present indications are that a substantial run will return to Portage Creek in 1958 from the natural reproduction in 1954 of the transplanted stock. If the returns in 1958 corroborate these early indications of success, a successful transplant, capable of regenerating itself at a rate comparable to that of native runs will have been accomplished for the first time in the history of Fraser River artificial propagation work extending back to 1901.

It may be stated on the basis of well-founded knowledge that successful transplants of self-regenerating runs of Fraser River sockeye depend among other things on the duplication of migration distance and reproductive environment for both the donor and recipient streams. It has been demonstrated in several cases involving not only sockeye but other species of salmon that the time of migration is an inherited reaction and cannot be changed by transplantation to a different environment. On the basis of much evidence, most of which is yet unpublished, early spawning sockeye cannot be transplanted to environments timed for late spawning nor can sockeye migrating short distances be transplanted to areas requiring a long migration or vice versa. Adults might return in some cases but would not regenerate themselves at a competitive rate with native runs. In general it may be concluded that Upper River sockeye runs cannot be transplanted to the Lower Fraser River nor can Lower Fraser River runs be transplanted to Upper River areas.

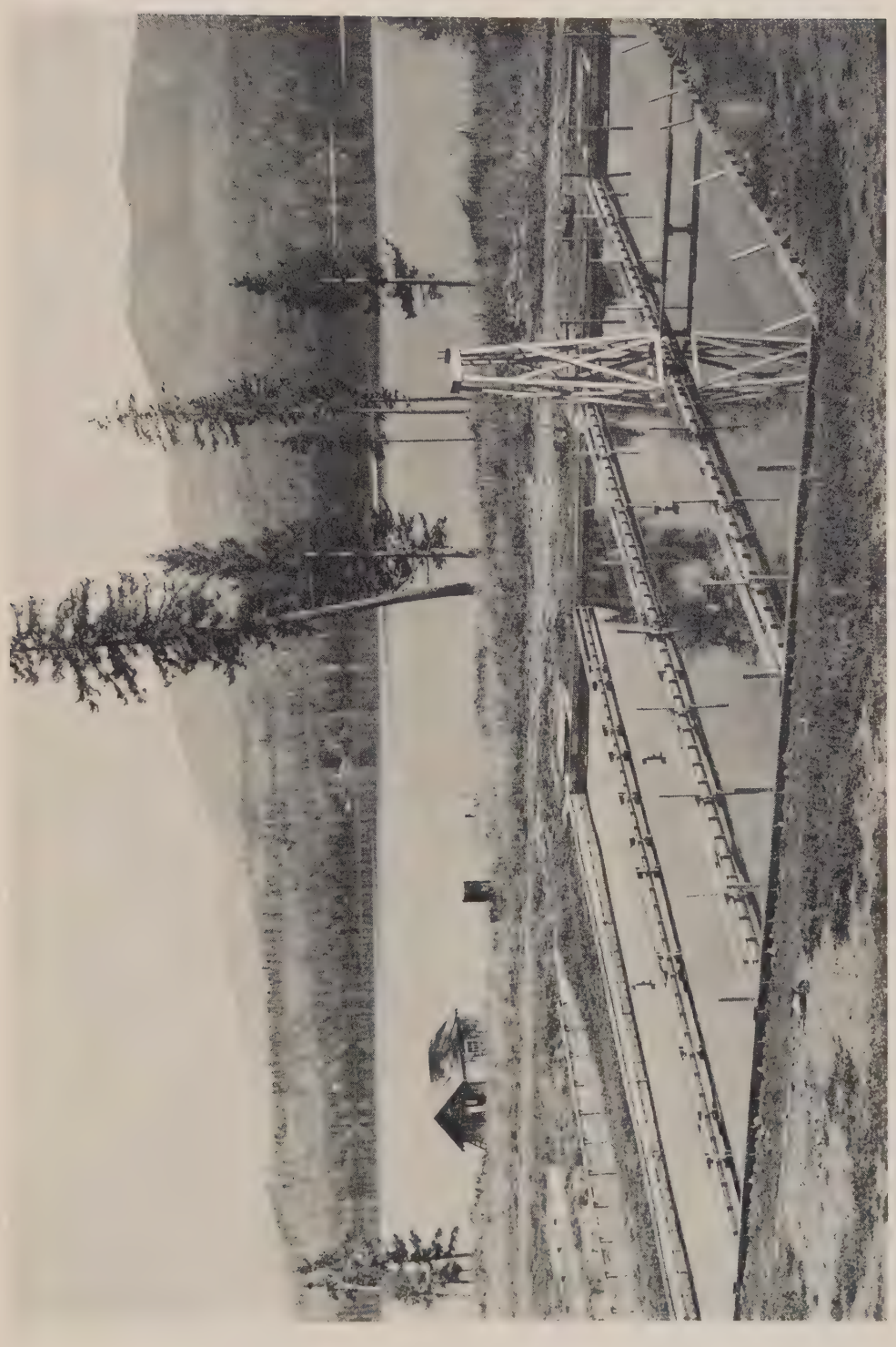
Evidence is abundantly available that artificial propagation will produce approximately nine times the number of salmon fry produced naturally. However, evidence is also available to show that seldom if ever do hatchery produced salmon fry survive at rates equivalent to naturally propagated fry. In fact the mortality rate of hatchery fish in most recorded instances is sufficiently greater than the mortality rate of naturally produced fish so that any theoretical advantage of producing nine times the number of fry by artificial propagation is often negated. Artificially propagated runs of sockeye salmon, even when released in the native stream, often fail to return in

numbers equal to similar sized runs regenerated naturally. The revelation of information on the low survival rates of artificially propagated sockeye salmon by Dr. R. E. Foerster of the Fisheries Research Board of Canada resulted in the Canadian Government discontinuing the artificial propagation of sockeye salmon in 1936.

One of the Commission's terms of reference calls for the extension of the sockeye fishery of the Fraser River watershed. In order to accomplish such extension of the fishery it appeared essential that the Commission consider artificial propagation or other artificial aids as a possible method of utilizing the full rearing potential of such lakes as Francois and Horsefly Lakes for young sockeye salmon during their required year of lake residence. Francois and Horsefly Lakes as well as certain other lakes in the Fraser watershed either have insufficient tributary spawning grounds or are devoid of spawning ground in which sockeye fry can be produced for utilizing the potential rearing capacity of those lakes. To meet the challenge of devising artificial aids for extending the sockeye fishery as well as providing a center of operations for restoring exterminated stocks of sockeye salmon, the Commission established the Quesnel Field Station on Horsefly Lake in 1949. The Commission recognized at the outset of the planning for this experimental station that artificial aids as a complete substitute for fresh water environment could not conceivably be economically practical because of the fantastic cost of substituting artificial rearing for natural lake rearing during the required period of one year of fresh water existence. However, in an attempt to establish self-regenerating runs of sockeye in streams where the runs had been exterminated by the Hell's Gate obstruction, twelve different experiments using artificially propagated and reared sockeye fingerlings failed in their purpose of returning a transplanted stock of sockeye spawners to the recipient stream.

Obviously if the known low rate of fry survival resulting from artificial propagation was to be increased, if successful artificial spawning grounds were to be designed, and if fingerling transplants were to be successful, a measure of the physical environment during natural propagation and incubation was essential. A measurement of the physiological effect of any known variations from natural environment surrounding the early life history of the sockeye brought about by the use of known artificial aids also appeared essential if the Commission was to successfully fulfill its terms of reference. A number of investigations on this subject have been completed and many more are under way or planned. In the meantime the restoration of former runs to spawning grounds no longer utilized because of the Hell's Gate obstruction is currently being undertaken by the method of transplanting eyed eggs. A summary of the findings of the experiments conducted to date at or in connection with the Quesnel Field Station and relating to the design of artificial aids capable of successfully extending the sockeye fishery of the Fraser River is as follows:

1. A study of the characteristics of water flow through gravel indicates that much of the high natural mortality occurring during the incubating egg stage and also the post-hatching stage is due to suffocation and is apparently non-selective in respect to the viability of the individual organism.
2. Exposure of film negative placed in normal spawning gravel at a depth where the sockeye egg is normally deposited failed to show a measurable penetration of light.
3. Sockeye eggs and alevins artificially incubated in complete darkness show decided physiological differences from eggs and alevins exposed diurnally to



Artificial spawning grounds at the Quesnel Field Station on Horsefly Lake. Flows and gravel sizes are varied in each of the sections as a part of the experiments to determine an ideal design for this type of artificial aid to sockeye propagation.

indirect daylight encountered in normal hatchery operations. Some of the observed major differences are as follows:

(a) The light-exposed eggs hatch earlier than the eggs incubated in natural darkness.
(b) The light-exposed alevins show a decided negative reaction to the light and constantly attempt to escape into a darker area if available.
(c) The light-exposed alevins are extremely active while the alevins in the dark environment are relatively inactive.
(d) The total mortality of eggs and alevins is greater when light-exposed.
(e) Tests of both terminal swimming speed and swimming endurance showed that the fry which had been exposed to light during incubation and the post-hatching period were significantly weaker than those which had not been exposed to indirect daylight.
(f) The light-exposed fry were smaller than the fry which had been produced in darkness and averaged one more vertebra.
(g) The light-exposed alevins reached the "emerging fry stage" earlier than did the dark exposed alevins.

4. Gravel size distribution in spawning beds has a significant effect on survival of incubating sockeye eggs and alevins. The elimination of "fines" under ¼ inch diameter greatly increases the porosity of the spawning medium. The artificial selection of gravel size to replace natural spawning grounds is probably not practical under natural stream flow variations.
5. Mature sockeye salmon will spawn successfully in an artificially prepared and temperature controlled spawning medium.
6. The sockeye fry survival rate from eggs incubated naturally in artificial spawning grounds averages four to eight times greater than from eggs naturally incubated in the native stream.
7. Selected gravel size ranging from ¼ to ¾ inch diameter when used in creating an artificial spawning ground appears to produce the highest rate of egg to fry survival.
8. Algal growths may be excessive in artificial spawning grounds and can be a major operating hazard unless a practical control method can be developed.
9. Rigid water temperature control in both hatchery and artificial spawning ground operation on the Fraser watershed is essential for eliminating excessive mortalities and to permit the transition of the alevins to the feeding fry stage at a time synchronized with the zooplankton cycle of the recipient rearing area. The provision of temperature control is a significant economic and operating problem.

The investigations of the Commission to date indicate that either hatcheries or artificial spawning grounds or both may be used as a tool for *extending* the sockeye fisheries of the Fraser River watershed. However, until the adverse physical factors surrounding the present day operational methods are fully recognized and eliminated by experimental research, the operational success of either method is in doubt. There is occasion for optimism in expecting that artificial fry production by some method will be developed which will substitute for insufficient or the complete lack of natural spawning grounds available in some natural lake rearing areas. There is

little hope, if any, of providing an artificial substitute of practical value for the loss of both natural sockeye spawning and rearing areas.

Transplantations of eyed eggs were made in the Upper Adams and Barriere Rivers during 1956. On October 12 and 13, 253,000 sockeye eggs eyed on the Seymour River were planted in the Upper Adams River near Mica Lake. On October 4, 5 and 6, 316,000 eggs taken from the Raft River stock and eyed on the Barriere River were planted in the latter stream.

Since the Nadina Lake watershed in the Francois Lake system does not have a native run of sockeye because of a high falls near its outlet, an attempt was made in 1956 to inaugurate a run to this area. A plant of 318,000 eyed eggs taken from Forfar Creek were flown to Nadina Lake in September, 1956 and planted in Creek X. The Nadina River will be observed in 1960 for early run sockeye and any observed will be placed manually over the falls. If a transplanted run is established, fishways can then be constructed on the falls and any artificial handling can then be eliminated.

WATERSHED PROTECTION

The protection of Fraser River sockeye from the possible deleterious effects of other water use developments within Convention waters presents an increasing number of problems every year, each requiring the careful attention of the Commission's staff. Proposals for the construction of hydroelectric power dams present the most serious potential source of injury to the sockeye runs due to the magnitude of the environmental changes such developments would create. However, other uses of the river system, such as industrial and agricultural water supply, waste disposal, placer mining, sand and gravel recovery, dredging, minor channel diversions and log driving, present a multiplicity of potential sources of damage to the fishery which, singly or in aggregate, could seriously reduce sockeye production if adequate remedial measures were not provided. The Department of Fisheries of Canada is vested with the legal authority to obtain fish protection in connection with water use developments while the Commission acts as a technical consultant to the Department in dealing with those projects affecting Fraser River sockeye. At the present time there are no known solutions to many of the problems that would be created by hydroelectric dams but satisfactory solutions to the other types of water use can generally be developed on the basis of experience and research and these range from simple solutions such as the timing of the operations to more complicated ones such as the treatment of industrial wastes.

During 1956 much interest was directed by public and private power companies to the possibility of development of hydroelectric power on the Fraser River and some of its tributaries. The B.C. Electric Company, through a subsidiary development company, made a grant of $50,000 to the University of British Columbia for a survey of existing knowledge and research on salmon fishery problems related to hydroelectric power developments on the Fraser River. The University invited men from business, the fishing industry, and from government agencies including the Commission, to participate on technical and advisory committees for the purpose of making the necessary surveys and recommending research projects which might be conducted under the terms of the grant. Four review reports on fisheries problems associated with hydroelectric dams were prepared by committee members on the University

staff for the consideration of these committees. These reports suggested a number of fields in which useful basic research on fishery problems might be undertaken by the University. The work of these committees was still in progress at the year's end.

Consideration of the proposal of the Moran Power Development Ltd. for the construction of a 720 foot high dam on the Fraser River at Moran required the full time use of several Commission scientists working with the staff of the Department of Fisheries. The proposed structure, located about 20 miles upstream from Lillooet, would obstruct the migration path of all but one of the major sockeye runs. The runs above the dam site are currently the source of almost 40 per cent of the Fraser River sockeye production and are worth $7,300,000 annually to the fishing industry. Once the runs have been developed to their maximum production level, based on pre-1914 production, they will provide 60 per cent of the Fraser River sockeye catch and be valued at $21,700,000 annually at current wholesale prices. The magnitude of the proposed dam and its direct relationship to the Fraser River sockeye fishery required a detailed examination and a careful evaluation on the basis of all available and relevant information of all the fishery problems that would be created. Research is already underway on some of the problems that have been revealed by the studies to date and activity in this field will increase in the coming year.

In the latter part of the year the B.C. Power Commission forwarded to the Department of Fisheries, for consideration, a proposal for the development of power from the Chilko and Taseko Lake watersheds by means of a diversion to coastal rivers. This new proposal was a modification of the scheme originally envisaged by the Water Rights Branch with provisions which, it was contended, would protect the important Chilko River sockeye runs from any deleterious effect. The Commission is carefully investigating the proposal and the results of the investigations will be made available to the Department of Fisheries together with suggestions as to how power could be developed in the area without significant effect on the fishery. As much as 815,000 h.p. could be developed from the waters of the Taseko River alone without significant effect on the fishery provided the water is not introduced into Chilko Lake. A small population of sockeye in Taseko Lake (less than 5000 spawners) would be lost if such a development is undertaken. However, Taseko Lake, with its extremely turbid water and limited beach spawning areas, would never become an important sockeye producing area and it was considered, in view of the need for general purpose power on Vancouver Island, that in this instance this small run could be sacrificed in the interest of preserving other more important sockeye runs.

The proposal to divert a portion of the Columbia River flow into the Fraser River system received much public attention during the year, and was one of several alternate methods of development of power from the Columbia River under study by the Canadian Section of the International Joint Commission. In late 1955, fisheries agencies in British Columbia prepared a report on this proposal for the Canadian Government in which it was emphasized that the diversion and the concomitant ten power dams on the Fraser and Thompson Rivers would destroy all the salmon runs to the Fraser River above Hope.

The new Seton Creek generating plant of the B.C. Electric Company commenced operation in the latter part of August (see frontispiece). This plant is located on the bank of the Fraser River near Lillooet, about one mile below the outlet of Seton Creek. It receives its water by canal from a diversion dam on Seton

Creek about three miles from its mouth. During the planning of this project, provisions were made for a fishway at the diversion dam and guaranteed minimum flows during migration, spawning and incubation periods. Provisions to prevent mortality to downstream migrants at the powerhouse and to overcome possible accumulation and delay of adult sockeye and pink salmon at the powerhouse were deferred pending further study once the project was in operation. The 1956 sockeye run to Gates Creek passed up Seton Creek and through the fishway prior to the starting of the plant so it was not possible to observe the effect of the powerhouse discharge on salmon destined for Seton Creek. However, a careful study of this problem will be made in 1957. A total of 9057 sockeye were counted through the fishway at the diversion dam and it was observed that the fish had some difficulty in finding the fishway entrance when, owing to the relatively small flow at the fishway there were large spills through the spillway section of the dam. However, this was an abnormal condition which would not occur under normal operation of the power plant.

Observations of sockeye migration and water temperature in the Nechako River below Fort Fraser were continued in 1956 to determine the effects of reduced flow resulting from the construction of Kenney Dam by the Aluminum Company of Canada. Studies prior to the construction of this dam indicated that the greatly reduced flows in the Nechako River below the dam could result in water temperatures higher than normal for given weather conditions, and in some years 68°F believed to be near the tolerance limit of the adult sockeye nearing their spawning grounds. Flow in the Nechako River at Vanderhoof during the summer months of 1956 was lower than any previous record despite releases of flows from the Skins Lake spillway ranging from 250 cfs up to 2750 cfs during the migration period. Apparently most of the water released was detained in natural storage in Cheslatta Lake. Water temperatures in the Nechako River were higher than any previously recorded as had been predicted with mean daily temperatures as high as 74°F in the middle of July, a few days prior to the start of sockeye migrations, and as high as 70°F for three days in the middle of August. However, the 1956 run of Nadina and Stellako River sockeye were in unusually good physical condition and arrived on the spawning ground without apparent damage. However it is known that the physical condition of these fish varies naturally from year to year and a future duplication of the 1956 temperatures and flow conditions could result in a serious loss. One meeting was held with the Aluminum Company during the year to discuss plans for spills from the Nechako reservoir during the coming winter and spring. The reservoir was not expected to reach full capacity until the spring of 1957.

Experiments in the use of a galvanotropic electric screen for guiding downstream migrants at large dams were continued in the spring months at Baker Dam. These experiments are being conducted by the Commission in cooperation with the Departments of Fisheries of Canada and the State of Washington as part of its program of investigating fishery problems associated with dams. An electric screen 200 feet long and 50 feet deep was used in conjunction with an enlarged by-pass capable of discharging up to 250 cfs, or about ten times the discharge of the by-pass used in 1955. This by-pass was found to be more efficient than the smaller one previously used, but the electric screen was again found to be ineffective for leading or guiding migrants to the by-pass. However, it was found that a simple webbing barrier 200 feet long and 15 feet deep was more effective in guiding migrants than the electric screen.

Because of the failure of the electric screen in each of three field seasons of study at Baker Dam, the Commission has decided to discontinue investigations of its use unless significant advances are made by other agencies conducting similar research. Plans are being made for the testing in the spring of 1957 of a webbing barrier 30 feet deep in the forebay of Baker Dam in conjunction with the improved by-pass.

Research continued during the year on the characteristics of the gravel redds in which sockeye eggs are incubated. This work is being done to investigate the reasons for the low natural survival of eggs in the nests as compared with survival in hatcheries or artificial spawning grounds. If the causes of the low survival can be determined and corrected, considerable increase in the size of sockeye runs may be possible. The survival of eggs in and emergence of alevins from various types and depths of gravel was studied to measure possible differences in survival due to these variables. The hydraulics of flow of water through a section of stream bed was also studied in a hydraulic model to determine the manner of interchange of fresh water from the stream above since fresh, well-oxygenated water is essential to the survival of eggs and alevins. A meter, based on the principle of dilution of an electrolyte, was developed and calibrated for use in measuring the apparent velocity of water flowing through the gravel in spawning grounds. Through the collection of field and experimental data, the general requirements and characteristics of sockeye redds are fairly well classified but the meter will permit the collection of additional data regarding the characteristics of natural redds. Further research will be directed toward more localized aspects of flow and nest construction.

Study of the effect of silt on the survival of eggs continues, with attention directed toward the effect of turbidity due to soil particles which are not normally deposited on the stream bed but which may be carried into the gravel beds through the process of interchange of water between the stream and the bed.

Each year, through the cooperation of the Chief Gold Commissioner for British Columbia and the Department of Fisheries of Canada, all applications for placer mining leases in the Fraser River watershed are forwarded to the Commission for consideration and recommendation. In many cases the lease sites are not on sockeye producing streams and no protective measures are required. In other cases, conditions on the disposal of tailings and silt laden wash waters are recommended, and in some, where the lease would cause unavoidable damage to the fishery, objection to the granting of the licence is registered. Through the excellent cooperation of the Chief Gold Commissioner, these measures have successfully prevented any loss of sockeye production. As a result of considerable interest in gold placer mining in the Horsefly River above the present spawning grounds and in a large potential spawning area, studies were made of the effects of such operations on the Horsefly River sockeye run. A report was prepared for submission to the Chief Gold Commissioner describing the probable effects of the proposed operations and recommending protective measures. This report was favorably received by the Commissioner who thereupon acted to prevent damage to the sockeye run now being rehabilitated.

Through a cooperative arrangement with the Provincial Comptroller of Water Rights and the Department of Fisheries of Canada, notice of all applications for water use licences in the Fraser River watershed are forwarded to the Commission for comment and any necessary recommendations. These applications range from small diversions for irrigation, placer mining or gravel washing, to large diversions for

hydroelectric power or industrial water supply. The possible effects on the fishery of each application are carefully considered and, where necessary, remedial or protective measures are recommended. In many cases the only requirement necessary is screening of the intake to prevent young salmon from being drawn into the water system. However, in other cases the use of water is connected with activities such as waste disposal or the development of power which may seriously affect the fishery. In these cases, technical discussions are held with the applicant to develop satisfactory solutions to the fishery problems.

A meeting was held early in the year with Provincial Comptroller of Water Rights under the auspices of the Fisheries Department to discuss fisheries problems in the Salmon River, tributary to Shuswap Lake. Numerous licences have been granted in the past for diversions of water from Salmon River for the irrigation of farmlands and applications for new licences are continually being made. The manner of specifying the quantity of water allowed under each licence presented the possibility that the cumulative instantaneous demand of all licences might reduce the flow in Salmon River below the minimum necessary in areas where sockeye spawn. Therefore the Comptroller of Water Rights was advised of the desirability of provision in licences granted that would adequately protect the fishery interest in the river. The Comptroller outlined the measures that may be taken under provisions of the Water Act to protect the fishery interest when considered necessary.

Prevention of pollution in the Fraser River and estuarial waters frequented by sockeye presents an ever increasing problem in the maintenance of a suitable environment for salmon. In dealing with these pollution problems, the Commission works in close cooperation with the Department of Fisheries of Canada with whom legal authority is vested under provisions of the Fisheries Act, and also with the Provincial Department of Health wherever there is any overlapping of interest. It is anticipated that close liaison will be maintained with the newly appointed Provincial Pollution Control Board when it commences operation. During the year discussions were held with ten new industries regarding pollution-prevention measures considered necessary for the protection of the fishery and at these discussions the cooperation of industry was sought to develop mutually acceptable means of achieving the desired results. Finalized waste handling methods were approved by the Department of Fisheries for six industries and discussions are continuing with four others. During the year eleven applications under review by the Department of Fisheries for disposal of raw or settled domestic sewage were forwarded to the Commission for consideration. These applications are for small disposal systems for housing subdivisions, hospitals, hotels, etc., in areas not served by sewers, and since they do not normally constitute a threat to the fishery, they are generally approved, subject to future reconsideration and the requirements of the Department of Health.

Following the discovery of the high water block to the Early Stuart sockeye run in 1955 at the rapids 3 miles upstream from Yale, a survey of the block site was made in the spring of 1956 to obtain all the data necessary to plan remedial measures. It was found that four points of blockade existed, two on each bank in a short narrow reach of river in which water velocities were very high. Complete removal of the obstruction would require four fishways, but in view of the very infrequent occurrence of the block levels, it was concluded that corrective measures on the right bank alone would provide adequate protection for the current population in the early sockeye

runs. Two fishways may be provided on the left bank at a later date should the size of runs increase or other considerations indicate their need. Plans were prepared for two fishways on the right bank; one, a reinforced concrete structure similar to the left bank high level fishway at Hell's Gate, and the other, a trapezoidal rock cut with three concrete baffles for flow stabilization. Total cost of these structures was estimated to be $45,000. These remedial measures were recommended to the two governments for completion before July of 1957 in order to provide protection for the important dominant cycle Early Stuart run if required. The governments approved the remedial action and provided the additional funds required. After obtaining the necessary permits and clearances, excavation for the foundation started at the beginning of December and it is planned that the structures be completed before May 15, 1957.

The fishways at Hell's Gate and Bridge River Rapids required the usual maintenance attention of cleanout and minor repairs. In addition, the fish exit trash racks of the lower and middle left bank fishways at Farwell Canyon were fitted with stop logs in an attempt to prevent river and bank gravel from being deposited in the fishway during freshet period, and if successful, these stop logs will be left in place except during the period of salmon migration upstream. At the Weaver Creek siphon, an accumulation of logs resulting from floods in late 1955 was removed from around the siphon control valves. At Hell's Gate, a trestle 95 feet long was constructed over a ravine to carry the road being extended from the highway. The rough grade for the road is now about 60 per cent completed.

A total of 4805 people visited the Hell's Gate fishways during the year. Due to the increasing numbers of visitors to the site, it was felt that washrooms should be provided for the convenience of the public. This new building, which is located at the west end of the suspension bridge, was about 75 per cent completed at the end of the year and will be ready for use in the tourist season of 1957.

1956 PUBLICATIONS

1. Annual Report of the International Pacific Salmon Fisheries Commission for 1955.
2. Research Bulletin Number IX.
   Collection and Interpretation of Sockeye Salmon Scales, by R. I. Clutter and L. E. Whitesel.
3. Progress Report.
   Electric Screens for Adult Salmon, by F. J. Andrew, P. C. Johnson and L. R. Kersey.
4. Progress Report.
   Further Experiments with an Electric Screen for Downstream-Migrant Salmon at Baker Dam, by F. J. Andrew, P. C. Johnson and L. R. Kersey.

PRINTED BY
CAMPBELL & SMITH LTD.
820 RICHARDS STREET, VANCOUVER 2, B.C.